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Attorney Docket No. 3600-100

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Reissue Application of	)	Examiner: C. Verdier
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DAVID A. SPEAR ET AL.	)	Group Art Unit: 3745
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Appln. No.: 09/343,736	)	
	:	
Filed: June 30, 1999	)	
	:	
For: SWEPT TURBOMACHINERY BLADE	) :	Date: April 10, 2001

Commissioner for Patents
Washington, D.C. 20231

AMENDMENT AND
INFORMATION DISCLOSURE STATEMENT

Sir:

In response to the Office Action of October 16, 2000, the time for responding to which having been extended to April 16, 2001, by the enclosed Petition for Extension of Time, please amend the above-identified application as follows:

IN THE CLAIMS:

Rewrite reissue claims 4, 5, 10-12, 15, 16, 18, 20, 21, 23, 24, 27, 30 and 36, as follows:

4. A turbomachinery blade for a gas turbine engine fan comprising a plurality of blades mounted for rotation about a fan axis with neighboring blades forming passages for a working medium gas, wherein:

the blade has a configuration enabling the fan to rotate at speeds providing supersonic flow velocities in at least a portion of each passage causing the formation of a shock in the gas adjacent an inner wall of a case forming an outer boundary for the working medium gas flowing through the passages;

the blade has a leading edge with an intermediate region and a tip region beginning at an outward boundary of the intermediate region and extending to a tip end of the blade, the intermediate region being swept rearward at a sweep angle that does not decrease; and

the tip region is translated forward relative to a leading edge with the same sweep angle as the outward boundary of said intermediate region, to provide a sweep angle that causes the blade to intercept the shock.

5. The turbomachinery blade of claim 4, wherein throughout the tip region the sweep angle is less than the sweep angle at the outward boundary of the intermediate region.

10. A blade for a gas turbine engine fan comprising a plurality of blades mounted for rotation within a case circumscribing the blades and forming an outer boundary for a working medium gas flowing through passages formed by neighboring blades, wherein:

the blade has a configuration enabling the fan to rotate at speeds providing supersonic flow velocities in at least a portion of each passage;

the blade has a leading edge with an intermediate region and a tip region beginning at an outward boundary of the intermediate region and extending to a tip end of the blade, the intermediate region having a sweep angle that does not decrease from an inward boundary of the intermediate region to the outward boundary of the intermediate region; and

throughout the tip region the sweep angle is less than the sweep angle at the outward boundary of the intermediate region.

11. The blade of claim 10, wherein the intermediate region is swept rearward and the tip region is translated forward relative to a leading edge with the same sweep angle as the outward boundary of the intermediate region.

~~12. The blade of claim 10, wherein the intermediate region is swept forward and the tip region is translated rearward relative to a leading edge with the same sweep angle as the outward boundary of the intermediate region.~~

~~15. The blade of any one of claims 10 to 14, wherein the inward boundary of the intermediate region is coincident with a root end of the blade.~~

~~16. The blade of claim 10, wherein:~~

~~the intermediate region is swept rearward and the tip region is translated forward relative to a leading edge with the same sweep angle as the outward boundary of the intermediate region; and~~

~~the leading edge of the blade has an inner region beginning at a root end of the blade and extending to the inward boundary of the intermediate region, the inner region being swept forward.~~

~~18. A blade for a gas turbine engine fan comprising a plurality of blades mounted for rotation within a case circumscribing the blades and forming an outer boundary for a working medium gas flowing through passages formed by neighboring blades, wherein:~~

the blade has a configuration enabling the fan to rotate at speeds providing supersonic flow velocities in at least a portion of each passage;

the blade has a leading edge with an intermediate region and a tip region beginning at an outward boundary of the intermediate region and extending to a tip end of the blade, the intermediate region being swept rearward at a sweep angle that does not decrease from an inward boundary of the intermediate region to the outward boundary of the intermediate region; and

the tip region is translated forward relative to a leading edge with the same sweep angle as the outward boundary of the rearwardly swept intermediate region.

20. Turbomachinery for a gas turbine engine, comprising a plurality of blades mounted for rotation within a case circumscribing the blades and forming an outer boundary for a working medium gas flowing through passages formed by neighboring blades, wherein:

each blade has a configuration enabling the turbomachinery to rotate at speeds providing supersonic working medium gas velocities at least in the vicinity of the passages proximate to the case;

each blade has a leading edge with a swept intermediate region and a swept tip region beginning at an outward boundary of

C8

the intermediate region and extending to a tip end of the blade, the intermediate region of each blade having a sweep angle that does not decrease from an inward boundary of the intermediate region to the outward boundary of the intermediate region; and

G3

throughout the tip region the sweep angle of each blade is less than the sweep angle at the outward boundary of the intermediate region.

21. The turbomachinery of claim 20, wherein the intermediate region of each blade is swept rearward and the tip region is translated forward relative to a leading edge with the same sweep angle as the outward boundary of the intermediate region.

Sub C9

23. The turbomachinery of claim 22, wherein the leading edge of each blade has an inner region beginning at a root end of the blade and extending to the inward boundary of the intermediate region, the inner region being swept forward.

G4

24. The turbomachinery of claim 20, wherein the intermediate region of each blade is swept forward and the tip region is translated rearward relative to a leading edge with the same sweep angle as the outward boundary of the intermediate region.

Sub C10

27. A gas turbine engine fan comprising a plurality of identical blades, each blade being mounted for rotation within a case circumscribing the blades and having an inner wall forming an outer boundary for a working medium gas flowing through passages formed by neighboring blades, wherein:

each blade has a configuration enabling the fan to rotate at speeds providing supersonic working medium gas velocities in the vicinity of the passages proximate to the case;

each blade has a leading edge with an inner region, an intermediate region and a tip region, the inner region beginning at a root end of the blade and extending to an inward boundary of the intermediate region, and the tip region extending from an outward boundary of the intermediate region to a tip end of the blade; and

the inner region is swept forward, the intermediate region is swept rearward at a sweep angle that does not decrease, and the tip region is translated forward relative to a leading edge with the same sweep angle as the outward boundary of the intermediate region.

Sub C12

30. A blade for a gas turbine engine rotatable within a case at speeds providing supersonic flow over at least a

portion of the blade, wherein the blade has a leading edge with a rear swept middle region having a sweep angle that does not decrease throughout the middle region and ending at a tip region that is translated forward relative to a leading edge with the same sweep angle as the end of the middle region.

52 ~~36~~. A blade for a gas turbine engine rotatable within a case at speeds providing supersonic flow over at least a portion of the blade, wherein the blade has a leading edge with a forward swept middle region having a sweep angle that does not decrease throughout the middle region and ending at a tip region that is translated rearward relative to a leading edge with the same sweep angle as the end of the middle region.

REMARKS

Claims 4, 5, 10-12, 15, 16, 18, 20, 21, 24, 27, 30 and 36 have been amended. Claims 1-41 remain in the application.

The applicants would like to express their gratitude for the courtesies extended to their representative at the interview of April 2, 2001. The remarks that follow incorporate the discussion at the interview.

Except as specifically noted below, the amendments to the claims are made solely to address the points raised in the

rejection under 35 U.S.C. § 112, second paragraph. An Appendix, which shows the claim changes in the originally filed reissue claims by bracketing deleted claim language and underlining added claim language, is enclosed for the Examiner's convenience.

The applicants believe that the amendments made to address the various points raised in the Office Action regarding an alleged lack of antecedent basis in some of the claims are straightforward and do not require detailed explanation.

The rejection under § 112, second paragraph, contended also that reciting that the blade's tip region is "translated" fails to particularly point out and distinctly claim the subject matter the applicants regard as the invention. The claims have been amended at the pertinent locations to recite that this translation of the blade leading edge in the tip region is relative to a leading edge with the same sweep angle as the outward boundary of the adjacent inward region or portion of the blade.

The applicants' specification uses the term "translated" in the exact same context in which the claims use it to recite a blade feature in accordance with this aspect of the invention. See, for example, page 4, line 65, and Figures 2 and 5 of the present application.

The Examiner agreed at the interview that this language appeared to overcome the § 112 rejection based on this particular claim language.

Accordingly, the applicants respectfully submit that the claims as now written comply with all requirements of 35 U.S.C. § 112.

The present reissue application was filed with new independent reissue claims 4, 10, 18, 20, 27, 30 and 36, in addition to original claims 1-3. Claims 1-3 were allowed. Reissue claims 4 and 27 were not rejected on prior art grounds.

The remaining independent claims were rejected under 35 U.S.C. § 102 as being variously anticipated by U.S. Patent 2,660,410 to Hull, Jr., and U.S. Patent 4,714,407 to Cox et al. U.S. Patent 2,915,238 to Szydlowski was applied solely against claim 30. These rejections are all traversed for the following reasons.

In connection with all of these references, it is important first to keep in mind that the term "sweep," when used to define a property of the leading edge of a turbomachinery blade, has a very precise definition to one skilled in this art. Specifically, "sweep angle" at a particular radial location on a blade's leading edge refers to the angle formed at that location by (i) a line tangent to the blade leading edge in a plane

containing the relative velocity vector of the working medium gas and (ii) a plane normal to the relative velocity vector. The manner in which the present application, including the attached claims, use this term is illustrated in Figure 4 of the present application. Second Weingold Declaration at paragraphs 3-5. See also the present application at page 3, lines 20-29, and the First Weingold Declaration at paragraph 18.

In other words, the sweep angle of a blade leading edge is defined in terms of the velocity vector of the airflow approaching the blade. Therefore, it is necessary to know not only the blade geometry but also the characteristics of the flow environment (either by actual measurement or by computer simulation) in which the blade is operating, to determine the sweep angle profile of the blade's leading edge. Without knowing the flow conditions and the exact geometry of the blade, it is impossible to determine the leading edge sweep angle. Second Weingold Declaration at paragraph 6.

Turning first to Hull, it purports to describe a turbine bucket with increased structural stability. Hull says that the disclosed configuration "provides a blade which has been found to have unusual resistance to vibration in a tangential direction relative to the bucket wheel to which it is secured." Hull at column 4, lines 55-58. This, Hull says, is a consequence

of the tangential moment of inertia profile that results from the described blade configuration. However, Hull contains no disclosure that one of ordinary skill in the art would have interpreted as suggesting that the leading edge of the disclosed blade has any particular sweep angle profile. Second Weingold Declaration at paragraphs 7 and 8.

One of ordinary skill in the art would not have found the depiction of a turbine bucket in Hull's figures to impart any information regarding the sweep angle profile of the bucket's leading edge. That is, those skilled in the art, knowing that sweep angle cannot be determined without information about the blade's exact configuration <u>and</u> the characteristics of its flow environment (either by actual measurement or by computer simulation), would immediately recognize that Hull's simple pictorial representations are insufficient alone to impart information concerning the leading edge sweep angle profile of Hull's turbine bucket. This is in part because sweep angle depends on a particular three dimensional relationship of the velocity vector to the blade leading edge, as discussed above. There is no information whatever in Hull concerning leading edge sweep angle. Nor is there anything about the turbine bucket depicted in Hull's figures or the flow conditions discussed in Hull that would inherently and necessarily produce a particular

leading edge sweep angle profile. In other words, Hull contains insufficient information, either about the depicted turbine bucket's geometry or the flow conditions, for one of ordinary skill in the art to have been able to determine the leading edge sweep angle profile of Hull's turbine bucket. Second Weingold Declaration at paragraph 9.

The only discussion in Hull relating to angles formed between the disclosed turbine bucket and the flow over it relates to the entrance and exit flow angles of the three regions (2a,2b,2c) of the blade. Hull at column 3, lines 22-24, lines 47-50 and lines 63-65. Figure 4 of Hull shows that the entrance and exit angles depend solely on the angles at which the flow approaches the leading edge and leaves the trailing edge, respectively, in a plane taken at a radial section of the blade. It will be immediately apparent from a comparison of Hull's Figure 4 and the applicants' Figure 4 that the entrance and exit angles of Hull's bucket 2 are not the same as the sweep angle σ of the present invention. The appearance of Hull's turbine bucket in side elevation, even combined with knowledge of the flow entrance and exit angles (as defined by Hull), provides no insight into the values of the sweep angle of the bucket's leading edge. Second Weingold Declaration at paragraphs 10-12.

Turning now to the claims rejected over Hull, claim 10's blade has a leading edge with an intermediate region and a

tip region beginning at an outward boundary of the intermediate region. The sweep angle of the intermediate region does not decrease from an inward boundary of the intermediate region to the outward boundary thereof, and the sweep angle throughout the tip region is less than the sweep angle at the intermediate region's outward boundary. Claim 20 recites turbomachinery with a plurality of blades each of which has those features. Since Hull contains no teaching concerning sweep angle, one of ordinary skill in the art would not have read Hull to have suggested blades with leading edge profiles like those recited in the applicants' claims 10 and 20. Second Weingold Declaration at paragraph 13.

Claim 18 recites a blade that has a leading edge with a rear swept intermediate region and a tip region beginning at an outward boundary of the intermediate region. The sweep angle of the intermediate region does not decrease from an inward boundary of the intermediate region to the outward boundary thereof, and the tip region is translated forward relative to a leading edge with the same sweep angle as the outward boundary of the intermediate region. Claim 30 recites a blade with a rear swept middle region ending at a tip region. The sweep angle of the middle region does not decrease throughout the middle region, and the tip region is translated forward relative to a leading edge

with the same sweep angle as the end of the middle region. Since Hull contains no teaching concerning sweep angle, one of ordinary skill in the art would not have read Hull to have suggested blades with the leading edge profiles recited in claims 18 and 30. Second Weingold Declaration at paragraph 14.

The Office Action points to Figure 2 of Hull and, as understood, says that this side view suggests a blade having a leading edge with a rear swept intermediate region and a tip region with a sweep angle that either is less than the sweep angle at the outward boundary of the intermediate region or is translated forward from the end of the intermediate region. In other words, the Office Action indicates that Figure 2 suggests a blade that meets the above mentioned language of claims 10, 18, 20 and 30. Second Weingold Declaration at paragraph 15.

Actually, one skilled in the art would not have been able to tell anything about the sweep angle profile of the turbine bucket's leading edge from Figure 2 in Hull. Second Weingold Declaration at paragraph 16.

In the first place, even though it might seem at first glance that a direct comparison can be made between Hull's Figure 2 and the blade side view in the applicants' Figure 2, in reality that is not the case. For one thing, the applicants' specification notes that the sweep angles shown in Figure 2 are

actually "projections of the actual sweep angle onto the plane of the drawing." See the present application at page 3, lines 26-29. They do not depict sweep angle. Second Weingold Declaration at paragraph 16.

For another, Hull's entrance and exit angles only determine the relation of the velocity vector relative to the leading edge in a single plane. To be able to determine sweep angle, the radial component of the relative velocity vector must also be known, as well as the angle formed by a line tangent to the leading edge in a plane containing the velocity vector and a plane normal to the relative velocity vector. Hull simply does not contain enough information to make these geometric determinations. Id.

In addition, the blade shown in Hull is a turbine bucket, while the applicants' Figure 2 depicts a fan blade. While not all of the applicants' claims are limited to fan blades, those skilled in the art understand that a side elevation of a turbine bucket does not necessarily impart information about the sweep angle of the bucket's leading edge in the same manner as such a view of a fan blade. That is, the velocity vector approaching a turbine bucket reflects a completely different flow environment because the working medium is driving the turbine bucket to extract energy from the working medium. This contrasts

with the situation presented by a fan or compressor blade, which is imparting energy to the working medium. Accordingly, a direct comparison of Hull's figures and the applicants' figures is not relevant to the question of whether the turbine bucket in Hull's figures and the fan blade in the applicants' figures have similar leading edge sweep angle profiles. Moreover, the fact is that one of ordinary skill in the art would not necessarily understand the applicants' Figure 2 to disclose a particular leading edge sweep angle profile just from this depiction of a side elevation, without having additional information, such as parameters defining the blade's geometry and flow environment or a detailed discussion regarding the blade's leading edge profile such as is included in the applicants' specification. Second Weingold Declaration at paragraph 17.

Accordingly, it is believed that the applicants' claims are clearly patentable over Hull. Second Weingold Declaration at paragraphs 18 and 19.

Taking Cox next, it relates to turbomachinery blades, particularly for a turbine, having a trailing edge configuration that results in the streamlines of the gas flow through the turbine having a desired geometric relation to the trailing edge. Cox, like Hull, contains insufficient information, either about the blade geometry or the flow conditions, for one of ordinary

skill in the art to have been able to determine the leading edge sweep angle profile for Cox's blade. In other words, Cox contains no disclosure that one of ordinary skill in the art would have interpreted as suggesting a particular sweep angle profile for the disclosed blade's leading edge. Second Weingold Declaration at paragraphs 20 and 21.

The Office Action refers to Figure 10B of Cox as showing a particular leading edge profile. As has been discussed above, a blade's sweep angle cannot be determined simply by considering the appearance of the blade's leading edge when viewed from a particular perspective. Cox's Figure 10B is actually a rear elevation of the blade, as stated in Cox at column 3, lines 45-46. A better way of gaining insight into the relationship between Cox's blade and the applicants' invention is to consider the side elevation view in Figure 10D of Cox. This is the perspective most likely to be indicative of the sweep angle of the leading edge, but it shows a blade leading edge profile that looks nothing like that of the applicants' claimed blades. This can also be appreciated by comparing Cox's Figure 10D with the applicants' Figures 2 and 6, which show side elevations of embodiments of the applicants' blades. Accordingly, it cannot even be said about Cox that it suggests the applicants' invention because of a superficial similarity

between side views of the applicants' and Cox's blades. Second Weingold Declaration at paragraphs 22-24.

There is actually nothing in Cox that one of ordinary skill in the art would have found informative regarding the sweep angle of the described blade's leading edge, and Cox contains no disclosure that one of ordinary skill in the art would have interpreted as suggesting that the leading edge of the disclosed blade has any particular leading edge sweep angle profile. Second Weingold Declaration at paragraph 25.

Turning now to the claims rejected over Cox, claim 10 recites a blade that has a leading edge with an intermediate region and a tip region beginning at an outward boundary of the intermediate region. The sweep angle of the intermediate region does not decrease from an inward boundary of the intermediate region to the outward boundary thereof, and the sweep angle throughout the tip region is less than the sweep angle at the intermediate region's outward boundary. Claim 20 recites turbomachinery with a plurality of blades each of which has those features. Since Cox contains no teaching concerning sweep angle, one of ordinary skill in the art would not have read Cox to have suggested a blade with the leading edge profile recited in the applicants' claims 10 and 20. Second Weingold Declaration at paragraph 26.

Claim 36 recites a blade with a forward swept middle region ending at a tip region. The sweep angle of the middle region does not decrease throughout the middle region, and the tip region is translated rearward relative to a leading edge with the same sweep angle as the end of the middle region. Since Cox contains no teaching concerning sweep angle, one of ordinary skill in the art would not have read Cox to have suggested a blade with the leading edge profile recited in claim 36. Second Weingold Declaration at paragraph 27.

The Office Action points to Figure 10B of Cox and, as understood, says that it suggests a blade having a leading edge with a forward swept intermediate region and a tip region with a sweep angle that either is less than the sweep angle at the outward boundary of the intermediate region or is translated rearward from the end of the intermediate region. In other words, the Office Action indicates that Figure 10B suggests a blade that meets the above mentioned language of claims 10, 20 and 36. In reality, one skilled in the art would not have been able to tell anything about the sweep angle of the Cox blade's leading edge from Cox's figures. Second Weingold Declaration at paragraphs 28 and 29.

In the first place, even a direct comparison of the closest depiction in Cox to the applicants' blade (that is,

Figure 10D of Cox) clearly does not suggest the applicants' claimed invention. And even though it might seem at first glance that a direct comparison can be made between Cox's Figure 10D and the blade side view in the applicants' Figures 2 and 6, in reality that is not the case. As noted above, the applicants' specification says that the sweep angles shown in Figures 2 and 6 are actually "projections of the actual sweep angle onto the plane of the drawing." See the present application at page 3, lines 26-29. That is, they do not depict sweep angle. Second Weingold Declaration at paragraph 29.

In addition, the blade shown in Cox is primarily for use as turbine rotor or stator blade, while the applicants' Figure 2 depicts a fan blade. While not all of the applicants' claims are limited to fan blades, those skilled in the art understand that a side elevation of a turbine blade does not necessarily impart information about the sweep angle of the blade's leading edge in the same manner as a side view of a fan blade. Accordingly, a direct comparison of Cox's figures and the applicants' figures is not particularly informative. Second Weingold Declaration at paragraph 30.

Accordingly, it is believed that the applicants' claims are clearly patentable over Cox. Second Weingold Declaration at paragraph 31.

Turning to Szydlowski, it was used to reject claim 30. In response, claim 30 has been amended to clarify the intended scope of the claim language. Claim 36 has been similarly amended.

In the rejection based on Szydlowski, it appears that the Examiner was referring to the topmost blade on the compressor wheel 2 as seen in Figure 1 of Szydlowski. The Examiner deemed claim 30 to read on that blade.

Initially, it should be noted that Szydlowski, like Hull and Cox, has no teaching regarding sweep angle. Moreover, there is nothing inherent about the compressor or flow conditions disclosed in Szydlowski that would have led one skilled in the art to conclude that the compressor blades described therein have any particular sweep angle. Second Weingold Declaration at paragraph 32.

Nevertheless, even if the blade profile in Szydlowski's Figure 1 depicts the sweep angle of its leading edge, it is not the applicants' intention to claim such a blade.

Accordingly, claim 30 has been amended to clarify that the applicants' blade has leading edge with a sweep angle that does not decrease throughout a rear swept middle region. Accordingly, amended claim 30 is even more clearly patentable

over Szydlowski. Claim 36 has been similarly amended for a blade with a forward swept middle region.

The Examiner agreed at the interview that claim 30 is patentable over Szydlowski.

INFORMATION DISCLOSURE STATEMENT

The applicants wish to bring to the Examiner's attention U.S. Patent 6,071,077, listed on the enclosed Form PTO-1449. This patent claims priority from the same United Kingdom application as Rolls-Royce EP 801230, cited by the applicants in the information Disclosure Statement of January 5, 2000. As noted there, this priority date is after the effective U.S. filing date of the present application.

The $180 fee set in 37 C.F.R. § 1.17(p), as required pursuant to 37 C.F.R. § 1.97(c)(2), may be charged to Deposit Account No. 50-0409.

CONCLUSION

The applicants believe that this Amendment responds to all of the points raised in the Office Action and respectfully requests reconsideration and allowance of the present application, with claims 1-41.

Any fee associated with this Amendment may be charged to Deposit Account No. 50-0409.

The applicants' undersigned attorney may be reached by telephone at (609) 921-8660. All correspondence should be directed to the below listed address.

Respectfully submitted,

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APPENDIX TO AMENDMENT OF ARIL 10, 2001

4. A turbomachinery blade for a gas turbine engine fan comprising a plurality of blades mounted for rotation about a fan axis with neighboring blades forming passages for a working medium gas, wherein:

the blade has a configuration enabling the fan to rotate at speeds providing supersonic flow velocities in at least a portion of each passage causing the formation of a shock in the gas adjacent an inner wall of a case forming an outer boundary for the working medium gas flowing through the passages;

the blade has a leading edge with an intermediate region and a tip region beginning at an outward boundary of the intermediate region and extending to a tip end of the blade, the intermediate region being swept rearward at a sweep angle that does not decrease; and

the tip region is translated forward relative to a leading edge with the same sweep angle as the outward boundary of said intermediate region, to provide a sweep angle that causes the blade to intercept the shock.

5. The turbomachinery blade of claim 4, wherein [the tip region begins at an outward boundary of the intermediate region and] throughout the tip region the sweep angle is less than the sweep angle at the outward boundary of the intermediate region.

10. A blade for a gas turbine engine fan comprising a plurality of blades mounted for rotation within a case circumscribing the blades and forming an outer boundary for a working medium gas flowing through passages formed by neighboring blades, wherein:

the blade has a configuration enabling the fan to rotate at speeds providing supersonic flow velocities in at least a portion of each passage;

the blade has a leading edge with an intermediate region and a tip region beginning at an outward boundary of the intermediate region and extending to a tip end of the blade, the intermediate region having a sweep angle that does not decrease from an inward boundary of the intermediate region [the beginning] to the outward boundary of the intermediate region; and

throughout the tip region the sweep angle is less than the sweep angle at the outward boundary of the intermediate region.

11. The blade of claim 10, wherein the intermediate region is swept rearward and the tip region is translated forward relative to a leading edge with the same sweep angle as the outward boundary of the intermediate region.

12. The blade of claim 10, wherein the intermediate region is swept forward and the tip region is translated rearward relative to a leading edge with the same sweep angle as the outward boundary of the intermediate region.

15. The blade of any one of claims 10 to 14, wherein the [an] inward boundary of the intermediate region is coincident with a root end of the blade.

16. The blade of claim 10, wherein:

the intermediate region is swept rearward and the tip region is translated forward relative to a leading edge with the

same sweep angle as the outward boundary of the intermediate region; and

the leading edge of the blade has an inner region beginning at a root end of the blade and extending to the [an] inward boundary of the intermediate region, the inner region being swept forward.

18. A blade for a gas turbine engine fan comprising a plurality of blades mounted for rotation within a case circumscribing the blades and forming an outer boundary for a working medium gas flowing through passages formed by neighboring blades, wherein:

the blade has a configuration enabling the fan to rotate at speeds providing supersonic flow velocities in at least a portion of each passage;

the blade has a leading edge with an intermediate region and a tip region beginning at an outward boundary of the intermediate region and extending to a tip end of the blade, the intermediate region being swept rearward at a sweep angle that does not decrease from an inward boundary of the intermediate

region [the beginning] to the outward boundary of the intermediate region; and

the tip region is translated forward relative to a leading edge with the same sweep angle as [from] the outward boundary of the rearwardly swept intermediate region.

20. Turbomachinery for a gas turbine engine, comprising a plurality of blades mounted for rotation within a case circumscribing the blades and forming an outer boundary for a working medium gas flowing through passages formed by neighboring blades, wherein:

each blade has a configuration enabling the turbomachinery to rotate at speeds providing supersonic working medium gas velocities at least in the vicinity of the passages proximate to the case;

each blade has a leading edge with a swept intermediate region and a swept tip region beginning at an outward boundary of the intermediate region and extending to a tip end of the blade, the intermediate region of each blade having a sweep angle that does not decrease from an inward boundary of the intermediate

region [the beginning] to the outward boundary of the intermediate region; and

throughout the tip region the sweep angle of each blade is less than the sweep angle at the outward boundary of the intermediate region.

21. The turbomachinery of claim 20, wherein the intermediate region of each blade is swept rearward and the tip region is translated forward relative to a leading edge with the same sweep angle as the outward boundary of the intermediate region.

23. The turbomachinery of claim 22, wherein the leading edge of each blade has an inner region beginning at a root end of the blade and extending to the [an] inward boundary of the intermediate region, the inner region being swept forward.

24. The turbomachinery of claim 20, wherein the intermediate region of each blade is swept forward and the tip region is translated rearward relative to a leading edge with the

same sweep angle as the outward boundary of the intermediate region.

27. A gas turbine engine fan comprising a plurality of identical blades, each blade being mounted for rotation within a case circumscribing the blades and having an inner wall forming an outer boundary for a working medium gas flowing through passages formed by neighboring blades, wherein:

each blade has a configuration enabling the fan to rotate at speeds providing supersonic working medium gas velocities in the vicinity of the passages proximate to the case;

each blade has a leading edge with an inner region, an intermediate region and a tip region, the inner region beginning at a root end of the blade and extending to an inward boundary of the intermediate region, and the tip region extending from an outward boundary of the intermediate region to a tip end of the blade; and

the inner region is swept forward, the intermediate region is swept rearward at a sweep angle that does not decrease, and the tip region is translated forward relative to a leading

edge with same sweep angle as the [from] the outward boundary of the intermediate region.

30. A blade for a gas turbine engine rotatable within a case at speeds providing supersonic flow over at least a portion of the blade, wherein the blade has a leading edge with [has] a rear swept middle region having a sweep angle that does not decrease throughout the middle region and ending at a tip region that is translated forward relative to a leading edge with the same sweep angle as [from] the end of the middle region.

36. A blade for a gas turbine engine rotatable within a case at speeds providing supersonic flow over at least a portion of the blade, wherein the blade has a leading edge with [has] a forward swept middle region having a sweep angle that does not decrease throughout the middle region and ending at a tip region that is translated rearward relative to a leading edge with the same sweep angle as [from] the end of the middle region.